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(12) # EUROPEAN PATENT APPLICATION

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(54) **A single-axis or multi-axial apparatus for dynamic tests on large structures.**

(57) An apparatus for performing single-axis or multi-axial dynamic tests on large structures made of composite materials, which apparatus comprises, for each stress axis to be tested, a loading cable (1,7) for applying a force to a single-axis or multi-axial test-piece (6), either in tension or in compression, a hydraulic jack (3) for tensioning the cable (1,7), a structure (4) for anchoring the cable (1,7) optionally at discrete intervals along its length, a stopping and release device (13) for securing the cable (1,7) at one end before the test and for propagating a load wave to the test-piece (6) secured at the other end of the cable (1,7), a recoil shock-absorber (16), and at least one device (11,12) for limiting lateral oscillations of the cable (1,7).

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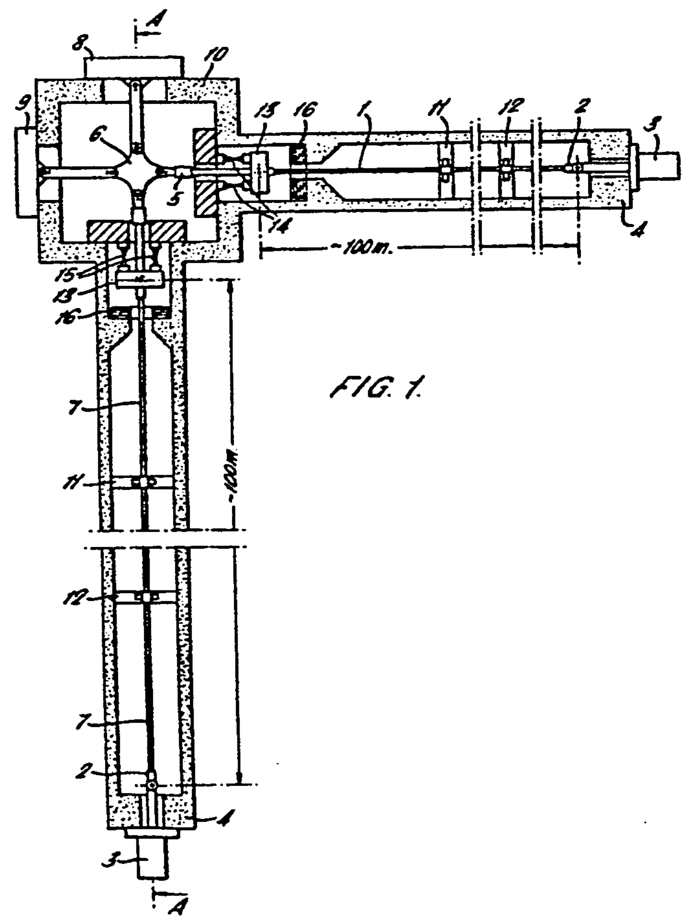

FIG. 1.

"A SINGLE-AXIS OR MULTI-AXIAL APPARATUS FOR DYNAMIC TESTS ON LARGE STRUCTURES"

The present invention relates to apparatus for performing single-axis or multi-axial dynamic tests on large structures.

The constituent dynamic equations are a very important parameter in the study of incidents in nuclear reactors and dynamically stressed structures in general. A knowledge of these equations is essential not only for homogeneous materials, such as steel, but also for composite structures such as a section of the reactor core or a reinforced concrete structure. A homogeneous material can be studied in small test-pieces, whereas in order to study a composite structure or material, it is necessary to have a relatively large cross-section in order to represent the entire material, which can then be considered as homogeneous.

In order to analyze the data and apply them to actual situations, it is also necessary to know the constituent equation under conditions of combined forces or with a stepped load diagram.

Test apparatuses exist for the first case (see Italian Patent Specification No. 985 074 dated 16th May 1973), but for the second case there are no known apparatuses which are adequate to perform tests requiring heavy loads, rapid application of the load, and a long duration of loading under conditions where the force of

the load is closely controlled. The apparatus described in the afore-mentioned patent is not suitable for direct application to heavy loads since the device for release of the load comprises a fragile intermediate member which has prohibitive dimensions. Furthermore, since the loads in question are large, special precautions are necessary with regard to the safety of the installation during testing, e.g. in the case of the hydraulic jack for tensioning the cable and the braking means for preventing the cable from being compressed.

To obviate the afore-mentioned limitations, the present invention provides a novel apparatus for studying the behaviour of materials with continually increasing stages of stress, and for investigating the strain hardening of materials due to successive plastic deformation thereof, with particular regard to the dynamics of large structures under heavy, rapidly changing loads.

According to the main feature of the invention the proposed apparatus comprises, for each stress axis to be tested, a loading cable for applying a force to the test-piece, either in tension or in compression, a hydraulic jack for tensioning the cable, a structure for securing the cable, optionally at discrete intervals along its length, a stopping and releasing device for securing the cable before the test and for propagating a load wave to the test-piece after the release mechanism has been actuated, a recoil shock-absorber, and at least one device for limiting lateral oscillations of the cable.

According to another feature of the invention, the cable-securing structure is a tubular structure which operates under compression.

According to another feature of the invention, the device for stopping and releasing the cable under tension comprises explosive bolts with electric detonators synchronized to a microsecond.

One embodiment of an apparatus according to the present specification is illustrated in the accompanying drawings, in which:-

Figure 1 is a general view of a biaxial embodiment of the apparatus and Figure 2 is a sectional, side view taken along the line AA of Figure 1.

Figure 1 shows a steel cable 1, acting as an energy accumulator, secured at one end 2 by a hydraulic jack 3 to a stationary reinforced-concrete holder 4. The other end 5 is mechanically connected to a test-piece 6 which, in the biaxial embodiment, is connected to another cable 7 at right angles to cable 1 and is secured by retaining means 8, 9 to a bunker 10. In the case of triaxial tests, there will be three cables and three retaining means for securing to the bunker.

In another embodiment of the machine, a double cable is provided for each direction of force and holds the test-piece 6 at either end (cruciform embodiment).

In the biaxial embodiment, cable 1 is held horizontal and secured by appropriate intermediate means 11, 12 disposed along its entire length (e.g. 100 m) at discrete intervals. A release mechanism 13 is disposed at the bunker end of the cable and comprises two electrically synchronized explosive bolts 14, 15 and a recoil shock-absorber 16 made up of springs in series and in parallel.

Figure 2 is a sectional, side view of the apparatus of Figure 1 taken along the line AA of Figure 1. Like

elements bear like numbers.

The loading cable 1 is relatively long, to provide a long-duration tension pulse. A suitable device for applying a load to the test-piece is used for tensile and compression testing. The cable is dimensioned so that it can easily reach a permissible load of several hundred tonnes, by taking advantage of the fact that the cable is made up of relatively thin wires which can bear high permitted loads.

The hydraulic jack 3 is required for tensioning the cable. The structure 4 bearing the axial force can comprise tubular structure operating under compression, or two stationary securing means at the ends. The stopping and release device 13, which holds the end of the cable before the test, can propagate a load wave to the test-piece secured at the end of the cable, after some securing means 14,15 has broken.

Release is obtained by exploding electric detonators placed in a recess inside each component (e.g. each explosive bolt)of the release mechanism, the components being electrically synchronized to within microseconds.

Owing to the large amount of energy that is involved, there may be danger to people or property if the cable is released completely, followed by a whiplash when the cable changes from a state of tension to a state of compression (in such cases the cable, which has just operated with a load at its end, bends rapidly sideways).

The recoil shock-absorber 16, made up of sets of springs in series or in parallel, prevents the cable

from changing over to the state of compression, and thus damps down the stresses which are continuously reflected after impact against the shock-absorber.

Additional protection against a whiplash is provided by the securing structures 11, 12 which limit the lateral motion of the cable. The stress axes can be parallel (shear forces) or variously inclined or at right angles or in different planes which may or may not be at right angles, so that a variety of stresses can be applied to the cross-section under test.

An alternative load device can comprises explosive charges synchronized with the action of the cable.

The protective bunker, which is the main stationary part of the machine structure, is an element common to all axes.

The intermediate means for securing the cable all the way along its length can be used for applying successive degrees of force when stressing the cross-section under test, the duration of the force being proportional to the length of the cable portions which are progressively released from the securing means.

The device can be used to study the behaviour of materials under continuously increasing states of stress, or more particularly for investigating strain hardening due to successive plastic deformation, or for studying relaxation phenomena.

CLAIMS:-

1. An apparatus for performing single-axis or multi-axial dynamic tests on large structures made of composite materials, which machine comprises, for each stress axis to be tested, a loading cable for applying a force to a single-axis or multi-axial test-piece, either in tension or in compression, a hydraulic jack for tensioning the cable, a structure for securing the cable optionally at discrete intervals along its length, a stopping and release device for securing the cable at one end before the test and for propagating a load wave to the test-piece secured to the other end of the cable, a recoil shock-absorber, and at least one device for limiting lateral oscillations of the cable.

2. An apparatus as claimed in claim 1 wherein the cable-securing structure is a tubular structure which operates under compression.

3. An apparatus as claimed in claim 1 or claim 2 wherein the cable-securing structure comprises two securing means attached to the ends of the cable and discrete intermediate securing means.

4. An apparatus as claimed in any one of the preceding claims wherein the device for stopping and releasing the cable under tension comprises explosive bolts with electric detonators synchronized to a micro-second.

5. An apparatus as claimed in any one of the preceding claims wherein the recoil shock-absorber comprises a plurality of springs disposed in series and/or in parallel.

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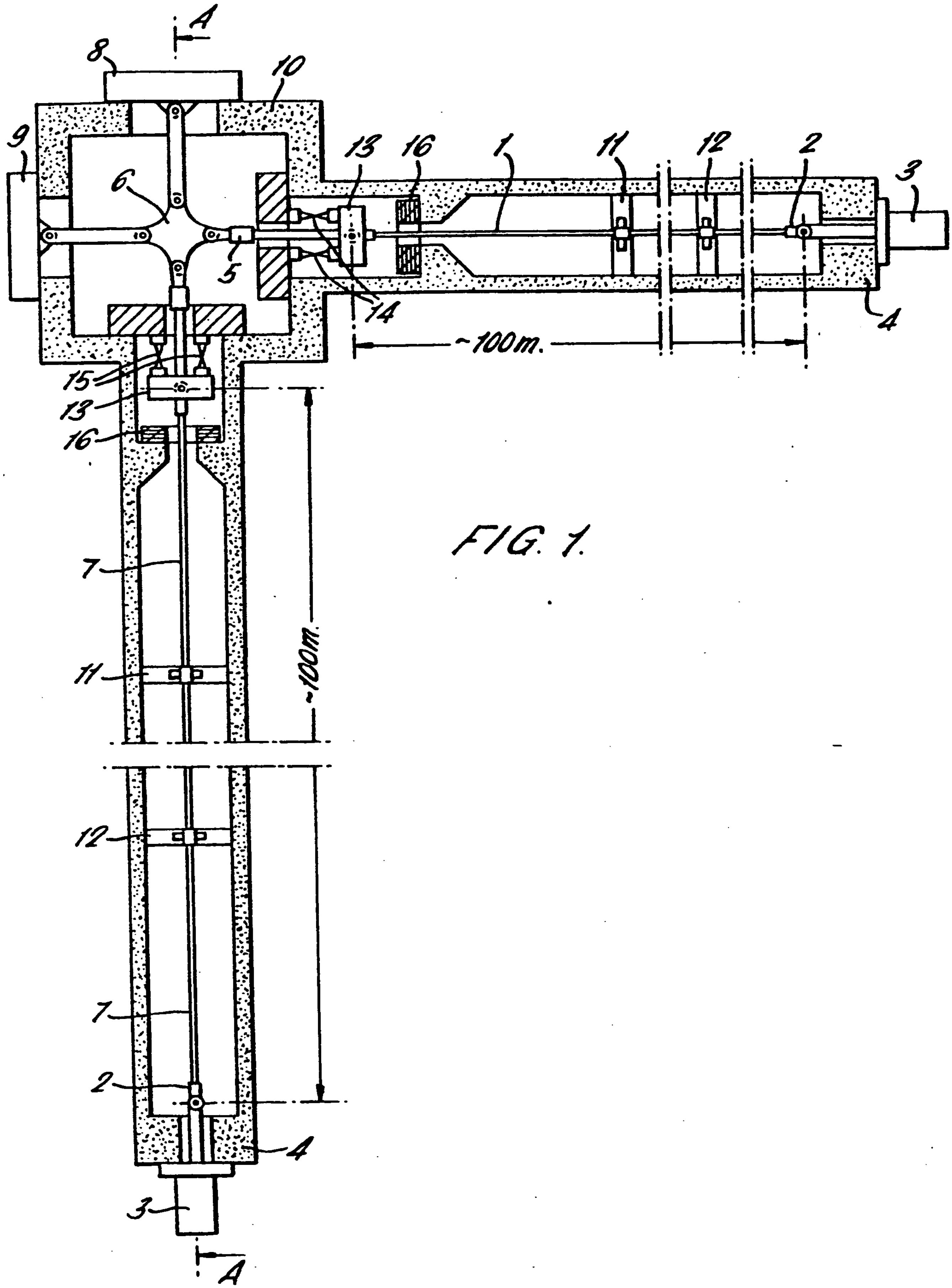

FIG. 1.

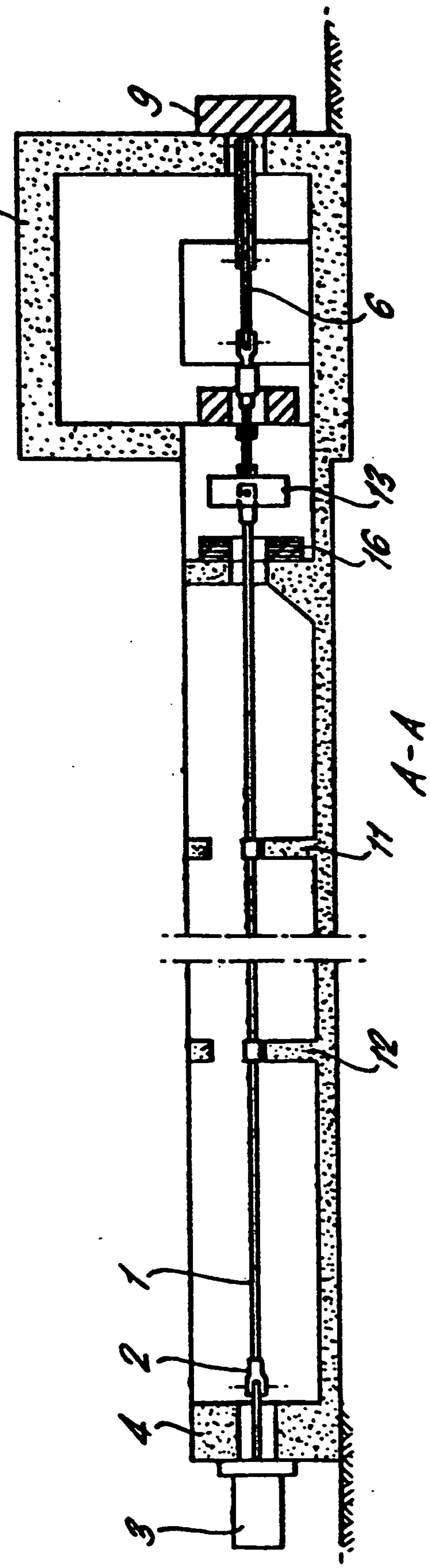

FIG. 2

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EUROPEAN SEARCH REPORT

Application number

EP 79 30 1353

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A	FR - A - 2 308 927 (EURATOM) * Claim 1; figures * --	1
A	FR - A - 2 194 965 (AGENCE NATIONALE DE VALORISATION DE LA RECHERCHE) * Claim 1; figures * --	1
A	MATERIALS TESTING, vol. 18, no. 4, April 1976, Dusseldorf DE H. WINKLER: "Testing machine for triaxial strenght studies on concrete specimens", pages 127-133 * Complete * --	1
A	WELDING JOURNAL, vol. 27, no. 11, November 1948, Miami, USA G. WELTER "Two new methods for testing triaxial specimens", pages 529 to 536. * Complete * --	1
A	FR - A - 2 229 967 (EURATOM) * Claim 1; figures * --	1
A	FR - B - 2 173 575 (EURATOM) * Claims 1 and 2; figures * --	1,4

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CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)

G 01 N 3/30
3/08

TECHNICAL FIELDS SEARCHED (Int.Cl. ³)

G 01 N 3/00
3/02
3/04
3/08
3/10
3/30
3/62

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28-09-1979	VAN ASSCHE

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EUROPEAN SEARCH REPORT

Application number
EP 79 30 1353
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A	US - A - 3 270 556 (E.K. HENRIKSEN) * Claim 1 ; figures * --	1,4
A	US - A - 3 407 651 (Y. SOPHY) * Abstract; figure * -----	1,4

CLASSIFICATION OF THE APPLICATION (Int. Cl. [3])

TECHNICAL FIELDS SEARCHED (Int. Cl. [3])